



Jack Kelley & Tom Braswell

jkelly@arl.army.mil & thomas.e.braswell@arl.army.mil

U.S. Army Research Laboratory
BLDG 4600, Deer Creek Loop
APG MD 21005

Luwam Hagos & Amy Fowler

luwam.hagos@navy.mil & amy.fowler1@navy.mil

U.S. Naval Air Warfare Center
NAVAIR, Code 4.3.4.2
48066 Shaw Road, Bldg. 2188
Patuxent River, MD 20670-1906



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Laboratory Validation and Demonstrations of Non-Hexavalent Chromium Conversion Coatings for Steel Substrates



NEW ORLEANS
February 8-10, 2011

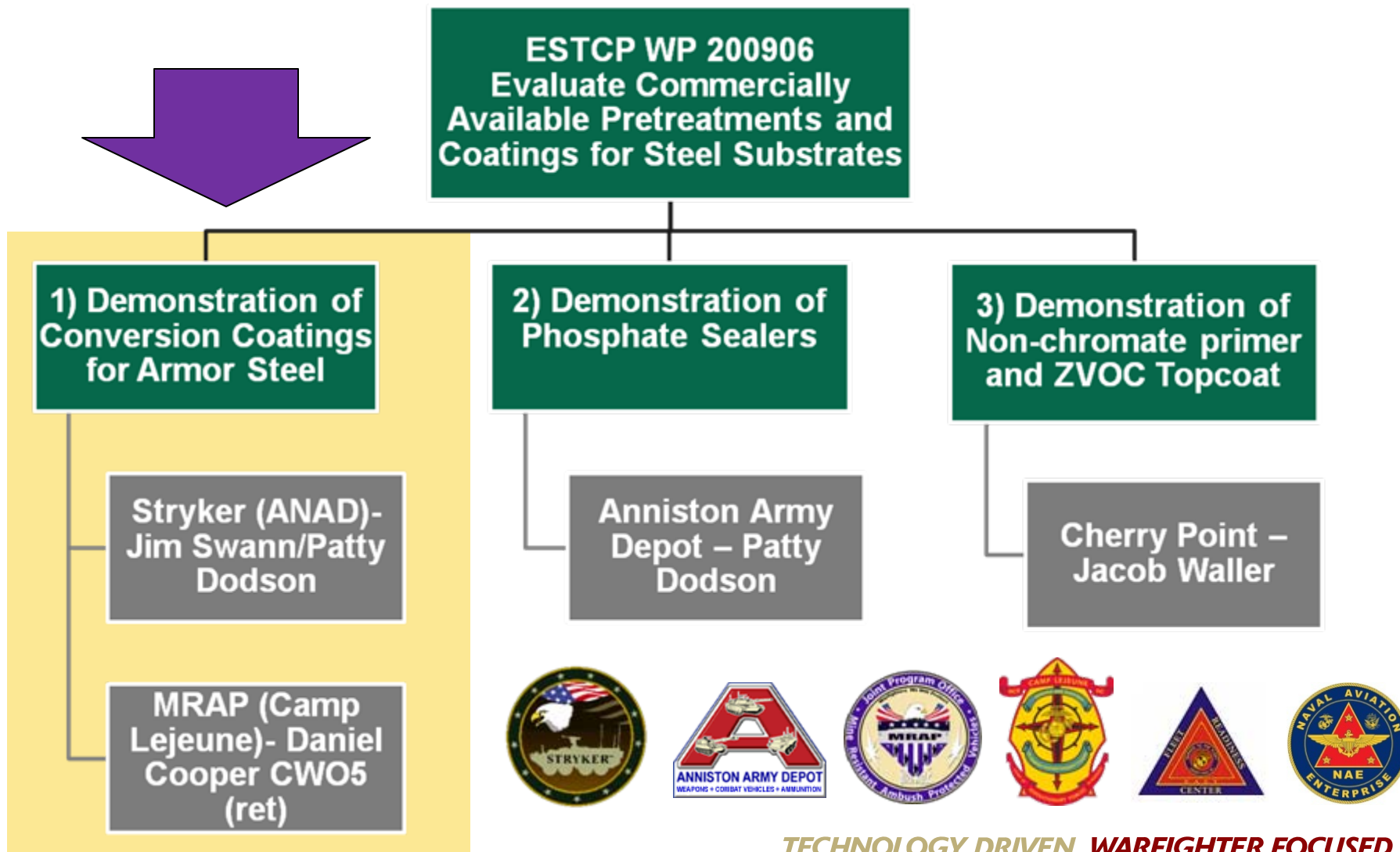
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- ✓ ESTCP WP 200906
- ✓ Background
- ✓ Laboratory Validation
 - Test Methodology
 - Results
- ✓ Ongoing and Scheduled Demonstrations
 - Stryker
 - MRAP
- ✓ Summary

Total of 3 Technology Areas Being Demonstrated



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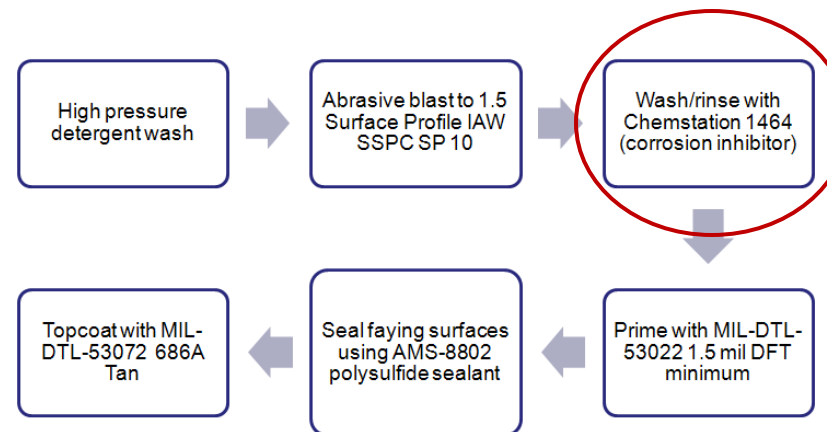
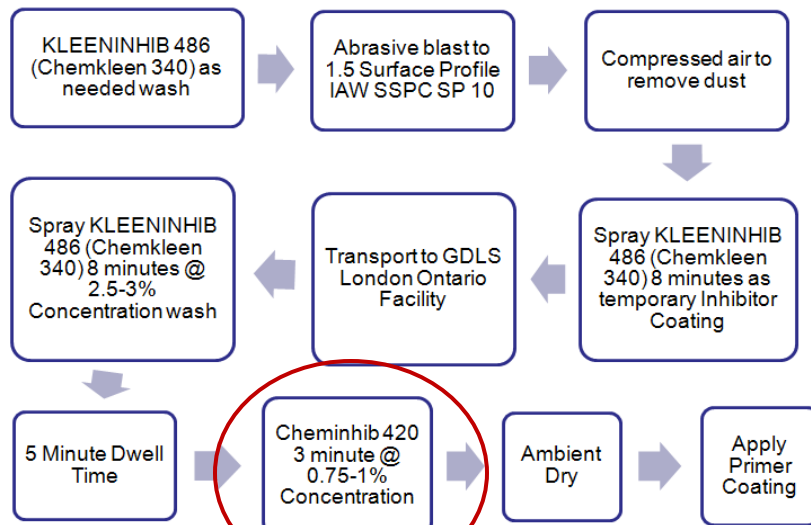
AR 750-12, requires all Army ground equipment coated with full (CARC) system.

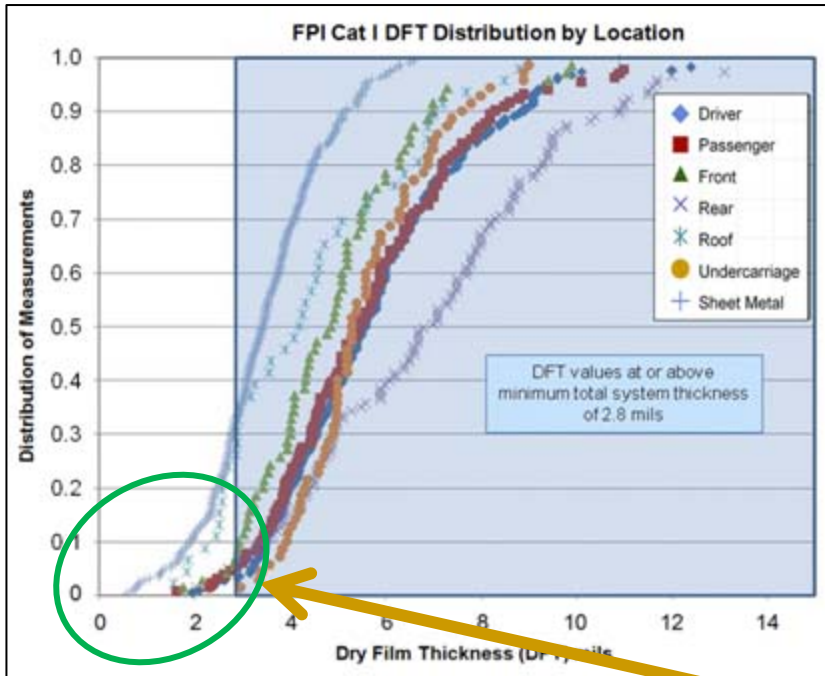
- The CARC system is defined in MIL-DTL-53072B:
 - a) A conversion coating or pretreatment in direct contact with a properly prepared substrate
 - b) Followed by an epoxy primer
 - c) Lastly, a polyurethane based topcoat MIL-DTL-53039 or MIL-DTL-64159.
- Coating exception/variation was granted to Stryker manufacturers and extended to MRAP giving permission to omit the pretreatment/conversion coating step.



Stryker Armored Vehicle
GENERAL DYNAMICS
Land Systems

Examples of Direct-to-Metal Processes





Pretreatment /conversion coatings omitted:

- Hex-chrome pretreatments prohibited for new ground vehicles
- Hydrogen embrittlement concerns
- Viable alternatives have not been fully field tested

No pretreatment makes process robustness diligence dependent:

- Type and condition of the blast media
- SP 10? 6? 7? degrades to? before applying inhibitor and painting
- The true dry film thickness (DFT)?

Poor coating practices leads to premature failures



Pretreatments will make process more robust

Steel Conversion Coatings

Candidate Conversion Coatings for HHA

- SurTec 650 - ChromitAL TCP
 - *Trivalent Chrome Pretreatment Developed by NAVAIR for Aluminum.*
- Chemetall Oxsilan 9810/2
 - *Non-chrome Organo-silane*
- PPG Zircobond 4200
 - *Non-chrome Zirconium-based steel conversion coating*

Baseline Steel Pretreatments:

- PPG Cheminhib 420
 - *Flash rust inhibitor used on Stryker*
- DOD-P-15328
 - *Chromate Wash primer*

Control Samples:

- *Untreated abrasive blasted surfaces*



Substrates: All pretreatments applied by manufacturer

- High Hard Armor MIL-A-46100
 - Charpys
- Low Carbon Steel A366

Corrosion Tests:

- Neutral Salt Fog – B117
- Cyclic Corrosion – GM9540P
- Flash Rust – Modified ASTM D 1735
- Humidity – ASTM D 2247-87
- **Outdoor Exposure (Cape Canaveral)**

Adhesion Test:

- Pull-Off Adhesion – ASTM D 4541
- Wet Adhesion – ASTM D 3359 Method A

Stress Corrosion Cracking:

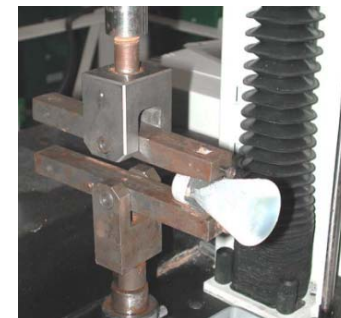
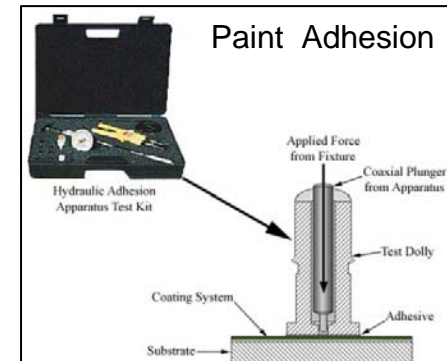
- Rising Step Load – ASTM F 1624-95

Chip Resistance:

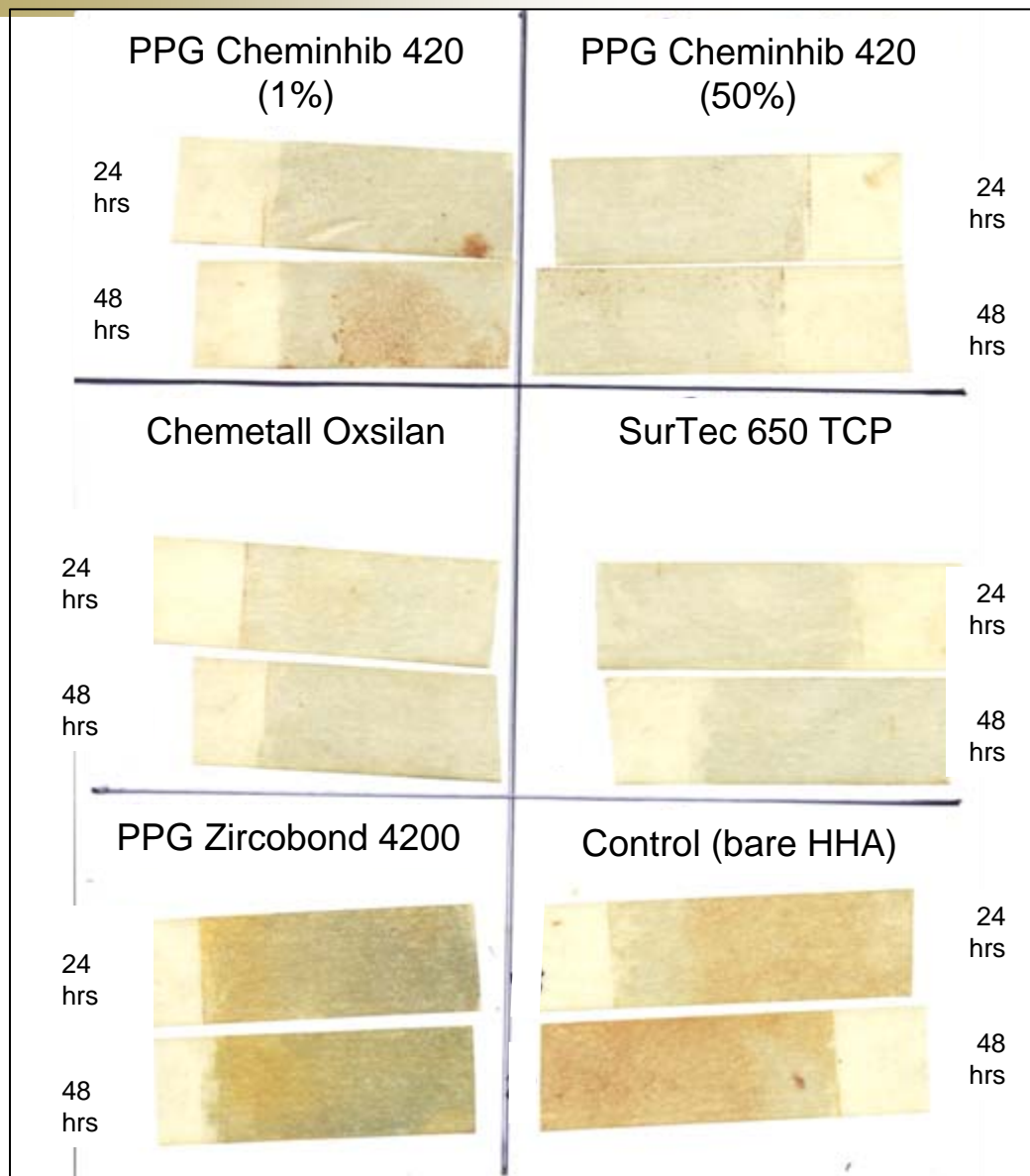
- Gravelometer – SAE-J400



Accelerated Corrosion Chamber



Rising Step Load



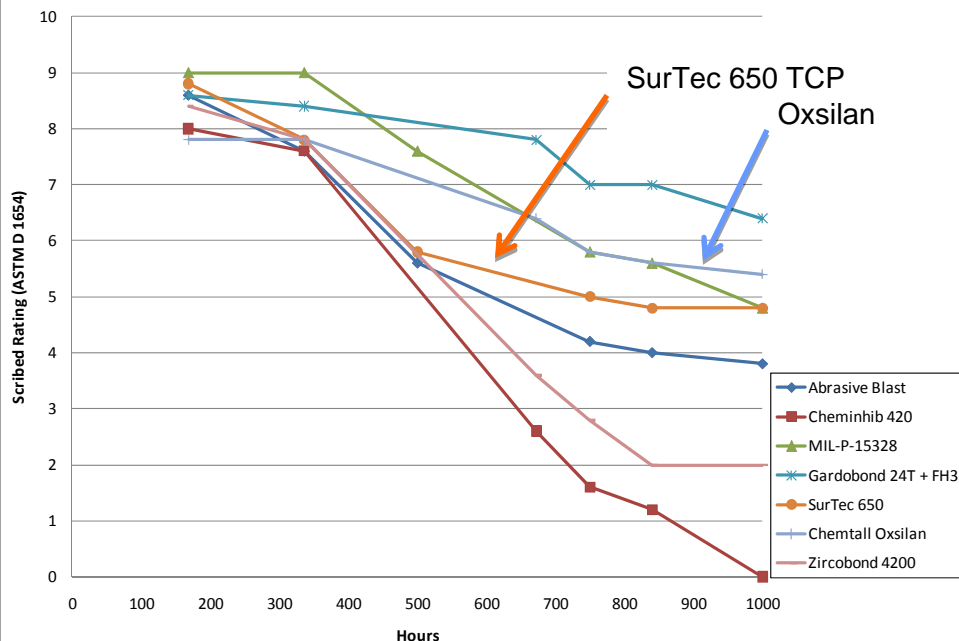
Humidity Test Results on Bare Abrasive Blasted HHA

- Modified version of ASTM D 1735
 - 90% RH at 100 Degrees F
- Used 3M pressure sensitive tape to capture flash rust

Results:

- No flash rust observed on either Oxsilan or SurTec 650
- Not clear if material pulled off Zircobond is corrosion or product residue
- Similar results through 96 hours of exposure

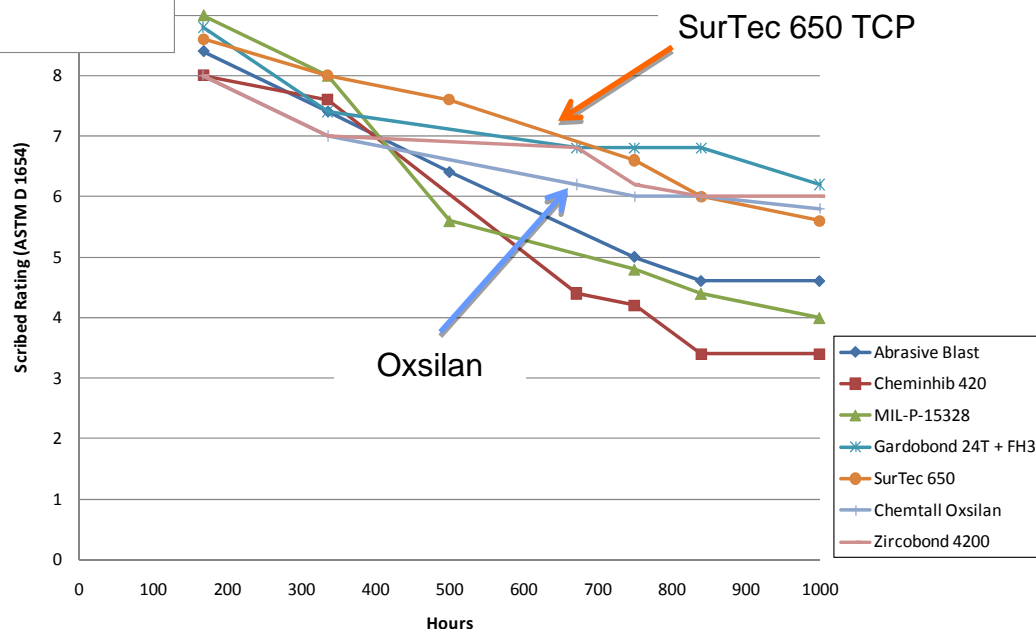
B117 Results on LCS over 1000 hours



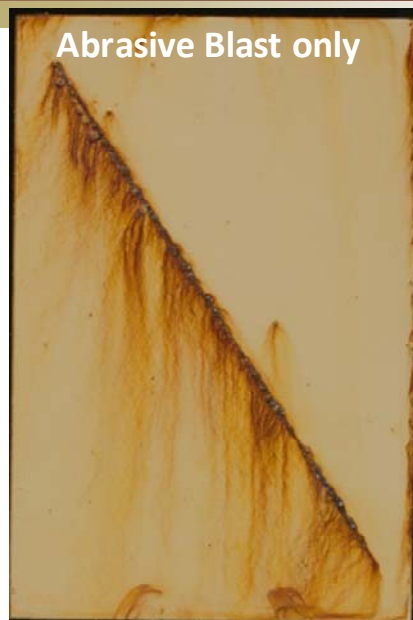
Laboratory Validation Results

ASTM-B117 results for pretreated steel panels and 53022/53039 CARC system

B117 Results on HHA over 1000 hours



B117 test results indicate TCP, Oxsilan and Zircobond all perform well on abrasive blasted HHA



Abrasive Blasted
HHA @ 750 hours
of B117 with
MIL-DTL-53022 /
MIL-DTL-53039

Pretreatment	AVG Ratings
Abrasive Blast	5
PPG 420	4.2
MIL-P-15328	4.8
SurTec 650	6.6
Oxsilan	6
Zircobond 4200	6.2

Cyclic Corrosion Test on HHA

ASTM-D1654 Ratings for abrasive blasted (1.5 mil surface finish) High Hard Armor (HHA) with MIL-DTL-53022 Primer and MIL-DTL-53039 Type III, Low VOC Topcoat

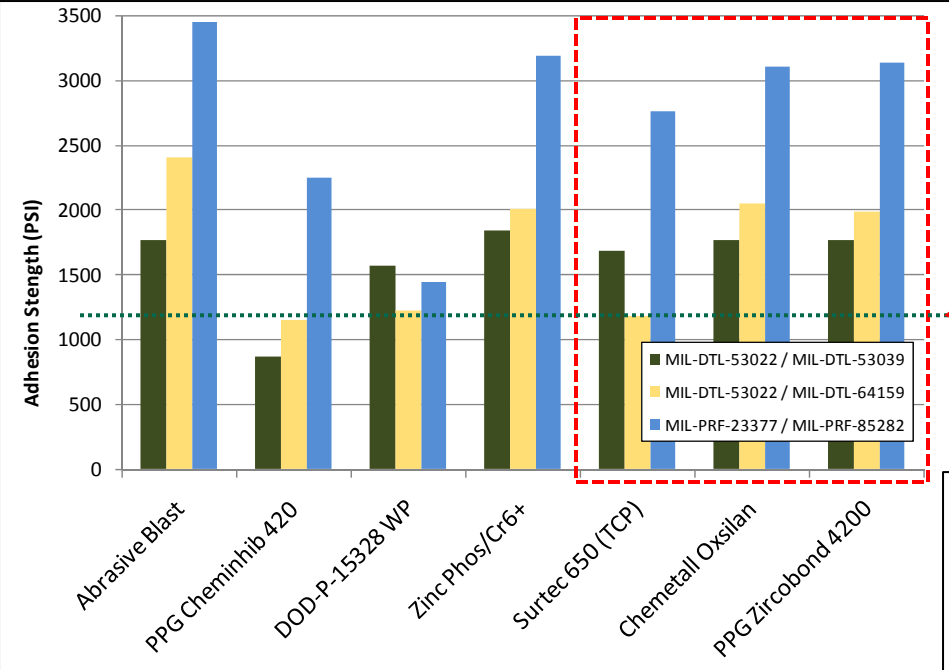
	Panel	Pretreatment	GM 9540P Cycles				
			10	20	40	60	80
Baselines	1	Abrasive Blast Only	7	6	4	2	0
	2		8	7	4	0	0
	3		8	6	5	2	0
	1	PPG Cheminhib 420	8	5	2	0	0
	2		7	5	3	2	0
	3		5	5	4	1	0
	1	DOD-P-15328	8	7	4	3	1
	2		7	5	4	2	0
	3		7	7	5	2	0
	1	Gardobond 24T + FH-3 (zinc phos/Cr6+)	8	8	6	6	4
	2		7	7	6	6	4
	3		7	7	6	6	5
Candidates	1	SurTec 650 (TCP)	7	7	5	4	2
	2		7	7	5	5	3
	3		7	7	5	4	2
	1	Chemetall Oxsilan	7	7	4	4	2
	2		7	7	5	4	2
	3		7	7	5	5	4
	1	PPG Zircobond 4200	7	7	5	5	2
	2		7	7	5	5	4
	3		7	7	6	6	4

- ASTM 1654 Ratings through 80 cycles of GM9540P



All candidate conversion coatings outperformed DOD-P-15328 Wash Primer

ASTM D 4541 Pull-Off Adhesion for LCS

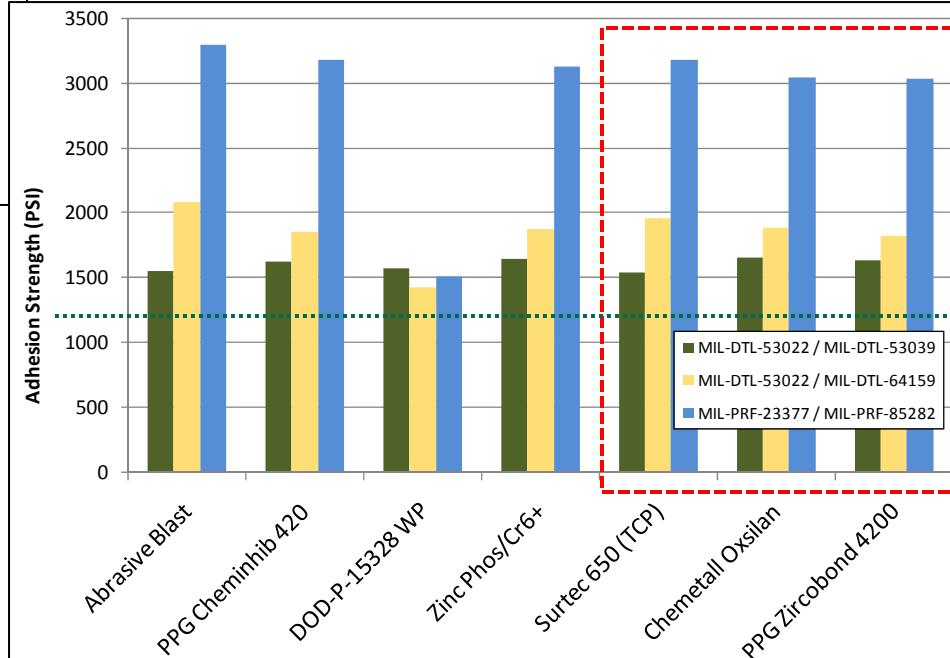


Laboratory Validation

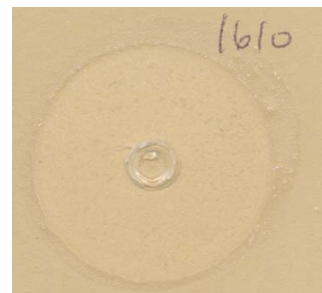
ASTM D 4541 results for pretreated steel panels with 3 paint systems

- Pull off values considered artificially low on CARC Beaded versions.
- Suspected glue/bead interaction
- Wash primer low point baseline (1200 psi)

ASTM D 4541 Pull-Off Adhesion for HHA

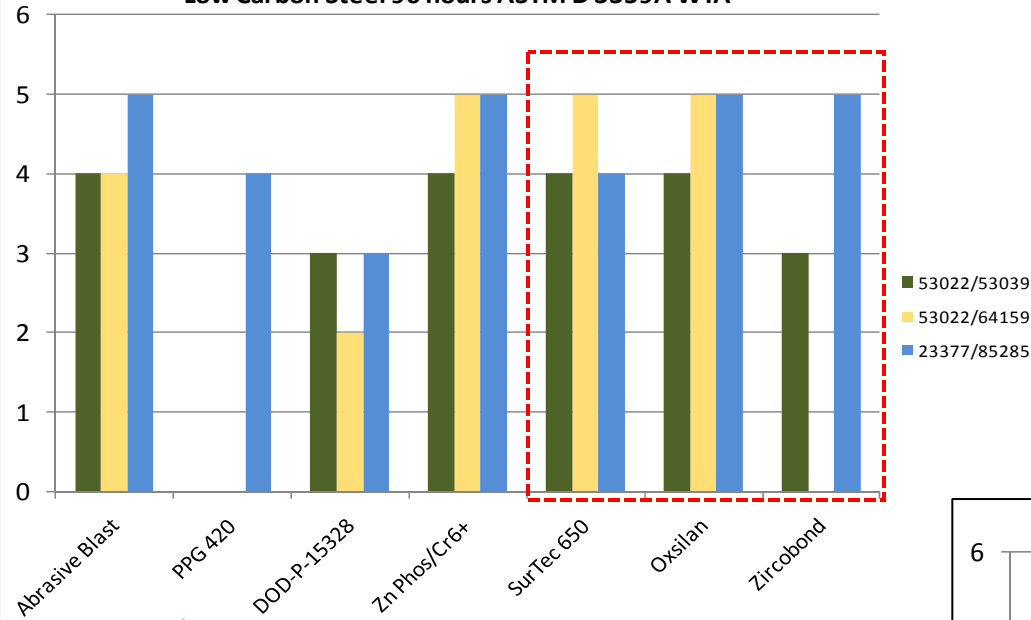


Chemihib 420 on LCS



Chemihib 420 on HHA

Low Carbon Steel 96 hours ASTM D 3359A WTA

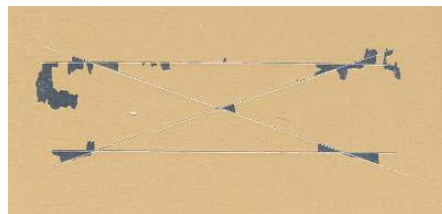
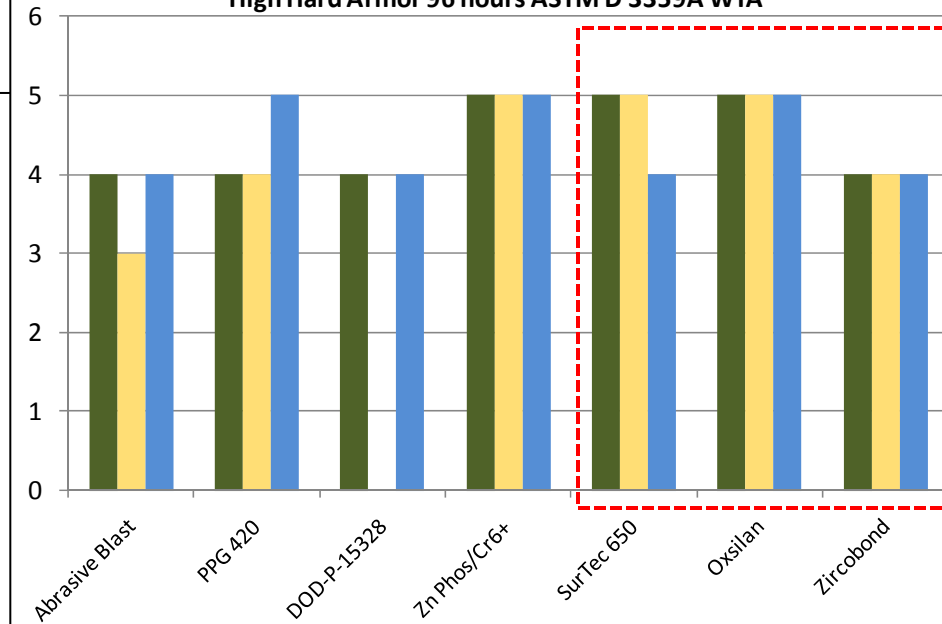


Laboratory Validation

Wet tape adhesion results for pretreated steel panels

- Only DOD-P-15328 with MIL-DTL-64159 had a complete failure on HHA
- All alternatives provided good wet tape adhesion on HHA

High Hard Armor 96 hours ASTM D 3359A WTA



PPG ChemInhib 420, LCS 96 hrs WTA (0)



DOD-P-15328 WP, HHA 96 hrs WTA (0)

Chip Resistance SAE-400J Gravelometer

Abrasive Blasted HHA						
	53022/53039		53022/64159		23377/85285 ZVOC	
Abrasive Blasted HHA	6	A/B	5	B/A	5	B
PPG Chem Inhib 420 HHA	5	B	5	B	5	B
DOD-P-15328 HHA	4	B/A	4	B	5	B
Gardobond 24T+FH-3 HHA	5	B	5	B/A	5	B/A
Gardobond 24S + CS100 + FH-3 HHA	4	A	4	B/A	4	B/A
Surtec 650 HHA	5	A	4	B/A	5	B/A
Chemetall Oxsilan HHA	5	B	5	B	5	B
PPG ZircoBond 4200 HHA	5	B/A	5	B	5	B/A
Milled Finish Low Carbon Steel						
	53022/53039		53022/64159		23377/85285 ZVOC	
Abrasive Blasted LCS	4	B	4	B	5	B
PPG Chem Inhib 420 LCS	5	C	4	C	5	B
DOD-P-15328 LCS	4	C	4	C	5	C
Gardobond 24T+FH-3 LCS	5	B	4	B	4	B
Surtec 650 LCS	4	C/D	4	C	5	C/D
Chemetall Oxsilan LCS	5	B	4	B/A	4	B
PPG ZircoBond 4200 LCS	5	B	5	B	5	B

Alternative conversion coatings demonstrate better-than or equal-to chip resistance than baselines





Demonstrations



Demonstration of Steel Conversion Coatings on HHA

• Stryker Vehicles:

- Stryker Demonstration Plan and JTP submitted Oct 18, 2010
- Demonstration of steel conversion coatings on Stryker initiated at ANAD Sept 2010

• MRAP Vehicles:

- Received signed Letter of Support from PMO MRAP
- Demonstration Plan submitted on January 31, 2011



DEPARTMENT OF THE ARMY
US ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND
ARMY RESEARCH LABORATORY
ABERDEEN PROVING GROUND MD 21005-5069

MEMORANDUM OF AGREEMENT
BETWEEN
THE U.S. ARMY RESEARCH LABORATORY,
WEAPONS AND MATERIALS RESEARCH DIRECTORATE
AND
PMO STRYKER BRIGADE COMBAT TEAM

SUBJECT: ARL and PM-SBCT MOA

1. REFERENCES:

- Annex A: Enhanced Coatings and Products for Environmental Compliance and Durability
- Annex B: Enhanced Coatings and Products for Environmental Compliance and Durability

Stryker Brigade Combat Team Corrosion Prevention and

Understanding partnership between ARL and PMO
Team for environmental compliance, enhanced
processes at OEM and depot facilities, and
Stryker Brigade Combat Team Corrosion Prevention and

ion of fielded Stryker assets and ever changing
cal, national, and international sources.

guidelines agreed upon under Annex A.
etermination may be made by mutual
organizations with 90 days written notice.
to this plan.

Kevin M. Fahey
KEVIN M. FAHEY
Program Executive Officer
Stryker Brigade Combat Systems



DEPARTMENT OF THE ARMY
UNITED STATES ARMY TANK-AUTOMOTIVE AND ARMAMENTS COMMAND
WARREN, MICHIGAN 48397-5000

15 Nov 2010

MEMORANDUM FOR: US Army Research Laboratory
SUBJECT: Memorandum of Agreement for considering the use of non-hex chromium
pretreatments for steel substrates on MRAP vehicles.

- PURPOSE: To formalize support of the US Army Research Laboratory (ARL) pretreatments for steel substrates on MRAP vehicles.

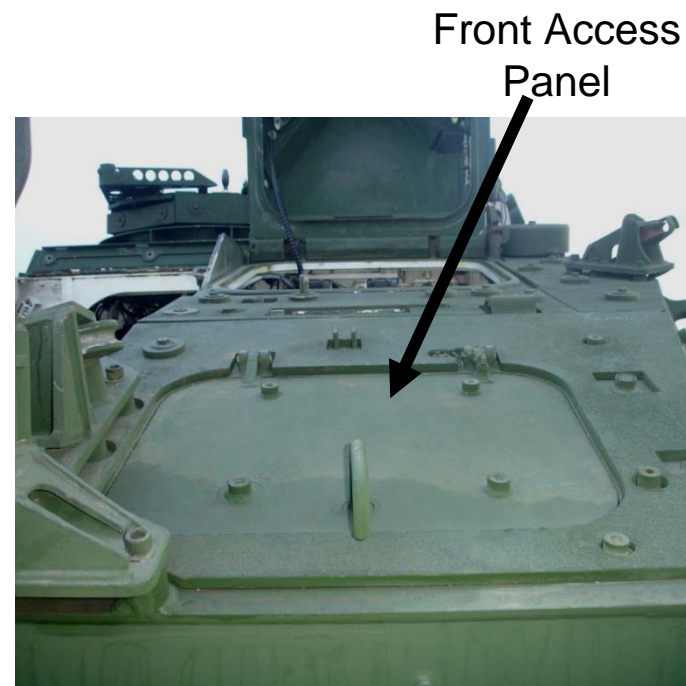
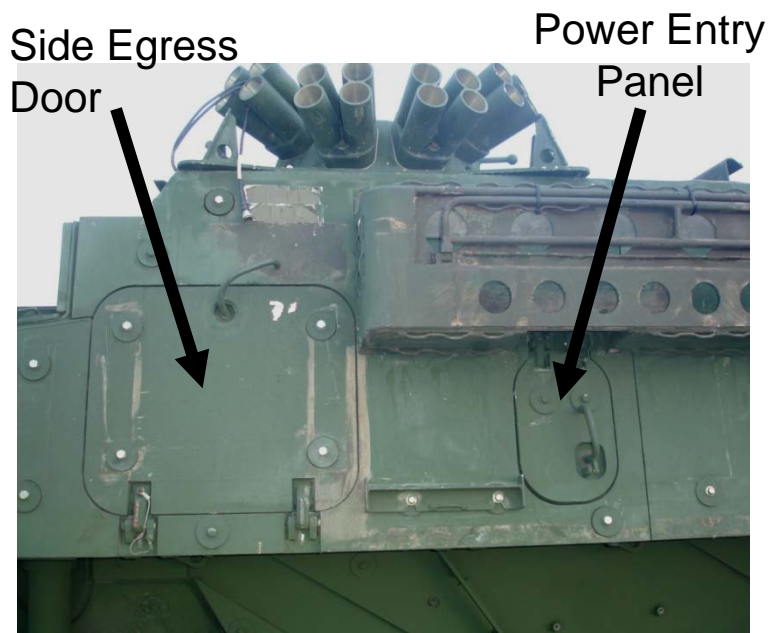
- PROBLEM: The current MRAPs were produced without a steel pretreatment/conversion coating step as added protection against corrosion and enhance paint adhesion. Hexavalent chromium based pretreatments such as DoD-P-15328 Wash Primer are typically prohibited for new ground systems and their corresponding service facilities. Furthermore, viable alternatives have not yet been fielded on actual high-hard armor based systems in order to be considered for implementation.

- SCOPE: The US Army Research Laboratory (ARL) is leading an effort to identify effective pretreatments for steel substrates, including High Hard Armor that are hexavalent chrome free. PM-MRAP supports ARL in their effort to identify, validate, and demonstrate these environmentally compliant pretreatments for steel for the purpose of enhancing the corrosion resistance of the chemical agent resistant coating (CARC) system used on MRAP vehicles. The PM's office is prepared to assist ARL in locating potential vehicles for demonstrations and provide a technical POC to represent the interests of MRAP as a stakeholder at scheduled Integrated Product Team (IPT) meetings. This office also will consider for implementation IPT recommendations in upcoming reset operations.

- POC for this action is Todd P. Weimer

Todd P. Weimer
Todd P. Weimer
Deputy Chief Engineer MRAP

Demonstration: Steel Conversion Coatings



Stryker Components Used in Demonstrations

Demonstration: Steel Conversion Coatings



Masking spill liner prior to abrasive blasting of high hard hatches



Application of chemical pretreatments

Component	Stryker Demonstration Vehicle Identification		
	MEV-76	MGS-25	ICV-382
Power Entry Panel (PEP) Hatch	SurTec 650 (TCP)	PPG Zircobond 4200	Chemetall Oxsilan
Front Access Hatch	PPG Zircobond 4200	Chemetall Oxsilan	SurTec 650 (TCP)
Side Egress Hatch	Chemetall Oxsilan	SurTec 650 (TCP)	PPG Zircobond 4200

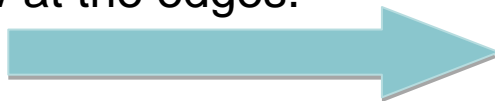


SurTec 650 TCP



Chemetall Oxsilan 9810/2

- Hatches shown immediately after pretreatment.
- Only Zircobond had a noticeable color change, a pinkish hue that turned yellow at the edges.



PPG Zircobond 4200

Treated hatches after 19 hours ambient “shop” exposure.
Weather conditions in Anniston Lo=51F Hi=81F @ 60-70% RH



SurTec 650 TCP



Oxsilan 9810/2



Zircobond 4200

- Received PMO Support (Nov 2010)
- Demonstration will be initiated at Camp Lejeune
- Meeting at Camp Lejeune (Jan 5, 2011)
 - Met with CWO5 Mark Schmidt
 - Obtained 2 complete MRAPs for Demonstration
 - Non-chrome conversion coating more desirable
- Demonstration Plan submitted to ESTCP on (Jan 31, 2011)
- Propose demonstration start date April 1, 2011



- Early indications are that all candidate conversion coatings will provide:
 - Better than baseline flash rust inhibition
 - Enhanced corrosion protection for HHA and LCS vs. DTM and wash primer DOD-P-15328
 - Improved adhesion of CARC vs. current DTM and wash primer
 - Equal or better chip resistance vs. baselines
- No additional step required vs. current processes used at OEM